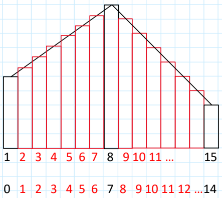
Exkurs: Bilineare Interpolation

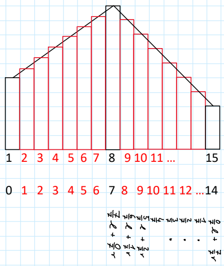
Tuesday, 13 December 2022 17:49

Zur Bilinearen Interpolation:

Bei uns: zur ansehnlichen Vergrößerung der Bilder um den Faktor 7 eingesetzt

Zur linearen Interpolation (schwarz - weiß Bild)
Zoomfaktor: 7





Wenn etwas linear ist, so kann man jeden Eintrag als a*linker Pixelwert+b*rechter Pixelwert darstellen.

Ganz analog geht das auch in 2D:

	7	6	5	4	3	2	1	0
7	7·7	7·6	7·5	7·4	7·3	7·2	7·1	7·0
6	6·7	6·6	6·5	6·4	6·3			6·0
5	5·7	5·6	5·5	5·4				5·0
4	4·7							4·0
3	3·7							3·0
2	2·7							2·0
1	1·7							1·0
0	0·7	0·6	0·5	0·4	0·3	0·2	0·1	0·0

ol or ul ur

Jeweils dividiert durch 7·7 ?

Komplette Formel für dieses Pixel:

$$\frac{5\cdot 6}{49}\cdot ol + \frac{5\cdot 1}{49} or + \frac{2\cdot 6}{49} ul + \frac{2\cdot 1}{49} ur$$

Dies sind die Gewichte für das Pixel oben-links (ol)

- Wie sehen die Gewichte für das Pixel or in diesem Bereich aus?

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Research Article

A Study of Digital Image Enlargement and Enhancement

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Most image enlargement techniques suffer the problem of zigzagged edges and jagged images following enlargement. Humans are sensitive to the edges of objects; if the edges in the image are sharp, the visual is considered to be high quality. To solve this problem, this paper presents a new and effective method for image enlargement and enhancement based on adaptive inverse hyperbolic tangent (AIHT) algorithm. Conventional image enlargement and enhancement methods enlarge the image using interpolation, and subsequently enhance the image without considering image features. However, this study presents the method based on Adaptive Inverse Hyperbolic Tangent algorithm to enhance images according to image features before enlarging the image. Experimental results indicate that the proposed algorithm is capable of adaptively enhancing the image and extruding object details, thereby improving enlargements by smoothing the edge of the objects in the image.

1. Introduction

The digital images are affordable and easy to preserve, transmit, and modify; they are widely used across different fields. Since digital image sampling is nonsequential and incomplete, digital image resolution is often limited. Therefore, it is necessary to employ image enlargement technologies when viewing portions of an image in detail.

The quality of an image is commonly determined by factors in the natural environment. Factors present in the natural environment usually relate to light. If light distribution is extreme, the target object in the picture becomes hard to identify. This study proposes an image enlargement method that combines image enhancement with image enlargement. The proposed image enhancement process employs AIHT algorithm to enhance the image and smooth its edges. The enlargement process uses a bilinear enlargement algorithm to enlarge the enhanced image. This method adaptively enhances images while simultaneously extruding details in the target image, in order to smooth the edges created by enlargement. Image quality is often reduced when images are enlarged. The proposed method can improve image quality following enlargement. The most significant advantage of this method is the ability to reduce rough edges and image distortion even after image enlargement.

This paper is structured as follows: Section 2 discusses related image enlargement technology algorithms; Section 3 introduces the AIHT algorithm; Section 4 describes the proposed algorithm; Section 5 presents the test and simulation results; the conclusion provides a closing discussion of the proposed algorithm and suggests future research directions and applications.

2. Review of Image Enlargement Algorithms

Images are enlarged to enhance image resolution, increase image quality, and improve identification. The goal of this approach is to maintain image quality while eliminating image distortion, such as blurring and rough edges, upon image enlargement.

Traditional interpolation methods are commonly employed in image enlargement due to their simplicity and efficiency. Interpolation generally comprises two methods: (1) nearest-neighbor interpolation [1] and (2) bilinear interpolation [2]. When the continuous function passes through, the interpolation function can be used to calculate the sampling points. In theory, higher order interpolation functions are similar to continuous functions. However, this is not the case in practice [3].

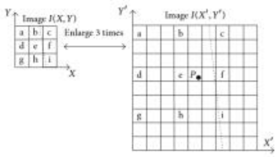

Figure 1: Nearest-neighbor interpolation method.

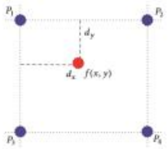

Figure 2: Bilinear interpolation method.

2.1. Nearest Neighbor Interpolation. Nearest-neighbor interpolation, otherwise known as the substitution method, uses the gray value of neighboring pixels to interpolate the gray value of new pixel points [4, 5]. This method's approach is to find the neighboring integer pixel points nearest to the noninteger pixel points. The gray value of these integer pixel points is then used to interpolate the gray value of new pixel points (shown in Figure 1).

In Figure 1 we can see the enlarged image (x', y') of the pixel P; then, with conversion back to the original image $I(x, y)$, P is interposed between the pixel e and f. Nearest-neighbor interpolation algorithm is to calculate the P point in the image $I(x, y)$ and its surrounding pixels e, f, h, and i the distance and then choose the shortest distance between the gray values of the pixels, as their gray values. The enlargement process using the nearest-neighbor interpolation algorithm will be encounter with the problem of blocking the effect.

The nearest-neighbor interpolation function is the simplest and most efficient interpolation algorithm. However, since it is easier to calculate its results in lower image quality, enlarged images usually display jagged and blocked features. The mathematical function is

$$h_r(t) = \begin{cases} 1, & -\frac{1}{2} < t < \frac{1}{2} \\ 0, & \text{otherwise.} \end{cases} \quad (1)$$

2.2. Bilinear Interpolation. In mathematics, bilinear interpolation is an extension of linear interpolation for interpolating functions of two variables on a regular 2D grid image. The key idea is to perform linear interpolation first in one direction and then again in the other direction. Although each step is linear in the sampled values and in the position, the interpolation as a whole is not linear but rather quadratic in the sample location.

In computer vision and image processing, bilinear interpolation is one of the basic resampling techniques. When an image needs to be scaled up, each pixel of the original image needs to be moved in a certain direction based on the scale constant. However, when scaling up an image by a nonintegral scale factor, there are pixels that are not assigned appropriate pixel values. In this case, those holes should be assigned appropriate RGB or grayscale values so that the output image does not have nonvalued pixels. Bilinear interpolation can be used where perfect image transformation with pixel matching is impossible, so that one can calculate and assign appropriate intensity values to pixels. Unlike other interpolation techniques such as nearest neighbor interpolation, bilinear interpolation uses only the 4 nearest pixel values which are located in diagonal directions from a given pixel in order to find the appropriate color intensity values of that pixel.

Bilinear interpolation considers the closest 2×2 neighborhood of known pixel values surrounding the unknown pixel's computed location. It then takes a weighted average of these 4 pixels to arrive at its final, interpolated value. The weight on each of the 4 pixel values is based on the computed pixel's distance from each of the known points (shown in Figure 2).

Similar to nearest-neighbor interpolation, this method calculates new values based on four neighboring integer pixels [6, 7]. Interpolation is calculated as follows:

$$\begin{aligned} f(x, y) = {} & (1 - d_x)(1 - d_y) p_1 + d_x (1 - d_y) p_2 \\ & + (1 - d_x) d_y p_3 + d_x d_y p_4. \end{aligned} \quad (2)$$

The $f(x, y)$ refers to the pixels of the new position point after image enlargement and p_1, p_2, p_3, and p_4 indicate the four vertices of the interpolation pixel p. The closer these vertices are to $f(x, y)$, the greater their contribution to $f(x, y)$ will be and vice versa. The neighboring pixels in images enlarged using bilinear interpolation are more continuous, or smoother, than when the integer points are acquired directly.

3. Adaptive Inverse Hyperbolic Tangent (AIHT) Algorithm

The world is filled with various images, which are representations of objects and scenes in the real world. Images are represented by a matrix of pixels, which can represent the gray levels or colors of the image. There are many aspects of images that are ambiguous and uncertain. Examples of these vague aspects include determining the border of a blurred object and determining which gray values of pixels are bright and which are dark [8]. If an image containing both objects and scenery gets too dark or blurred, it would be hardly recognized. Thus, the image enhancement technique